Claims

1. An apparatus for determining likelihood values of input data bits from a plurality of code symbols and a plurality of pilot symbols, comprising:

a memory element; and

a processor configured to execute a set of instructions stored in the memory element, the set of instructions for:

determining a gain vector relating the plurality of code symbols and the plurality of pilot symbols in accordance with channel characteristics; and

using the gain vector to determine likelihood values of a designated code symbol, wherein the input data bits are carried by the designated code symbol.

2. The apparatus of Claim 1, wherein using the gain vector to determine likelihood values of a designated code symbol comprises:

defining the likelihood values of the designated code symbol as a log likelihood ratio Λ_k in accordance with the following equation:

$$\Lambda_k = \log \frac{\max_{\vec{\theta},\{d_{\pi(j)}:j\in J-\{k\}\}} p_{\vec{\theta}}(\{x_j, y_{j'} : j\in J, j'\in J'\} \mid d_{\pi(k)} = +1, \{d_{\pi(j)} : j\in J-\{k\}\})}{\max_{\vec{\theta},\{d_{\pi(j)}:j\in J-\{k\}\}} p_{\vec{\theta}}(\{x_j, y_{j'} : j\in J, j'\in J'\} \mid d_{\pi(k)} = -1, \{d_{\pi(j)} : j\in J-\{k\}\})},$$

wherein $\vec{\theta}$ is the gain vector, $p_{\vec{\theta}}(\cdot \mid \cdot)$ is the conditional probability; $d_{\pi(k)}$ is the designated code symbol, x_j represents the plurality of code symbols, $y_{j'}$ represents the plurality of pilot symbols, and the indices J and J' are defined by:

$J \subseteq \{j : k - \underline{M} \le j \le k + \overline{M}\}$ and

$J' \subseteq \{j' : k - \underline{N} \le j' \le k + \overline{N}\}$,

where the terms $\underline{M}$, $\overline{M}$, $\underline{N}$, and $\overline{N}$ are window boundary values.

3. The apparatus of Claim 2, wherein the window boundary values $\underline{M}$, $\overline{M}$, $\underline{N}$, and $\overline{N}$ are equal.

4. The apparatus of Claim 2, wherein the window boundary value $\underline{M}$ equals the window boundary value $\overline{M}$ and the window boundary value $\underline{N}$ equals the window boundary value $\overline{N}$.

5. The apparatus of Claim 2, wherein the plurality of code symbols x_j and the plurality of code symbols $y_{j'}$ each comprise L components.

6. The apparatus of Claim 5, further comprising a RAKE "finger" assigned to each of the L components.

7. The apparatus of Claim 5, wherein the L components represent L multipath signals received on a single antenna.

8. The apparatus of Claim 5, wherein the L components represent L multipath signals received on two or more antennas.

9. The apparatus of Claim 5, wherein the L components represent L multipath signals received from two or more transmissions.

10. The apparatus of Claim 5, wherein the L components represent L multipath signals received from two or more carriers.

11. The apparatus of Claim 1, wherein determining the gain vector relating the plurality of code symbols and the plurality of pilot symbols in accordance with channel characteristics comprises:

evaluating a gain vector equation defined by:

$$\hat{\theta} = \frac{y + (1/N)(\sigma_p^2/\sigma_t^2)\left[\sum_{j \in J-\{k\}} g(x_j, \hat{\theta}) + d_{\pi(k)} x_k\right]}{1 + (M/N)(\sigma_p^2/\sigma_t^2)},$$

wherein σ_p^2/σ_t^2 is a pilot-to-traffic ratio, $g(\cdot,\cdot)$ is a predetermined function, $d_{\pi(k)}$ is the designated code symbol, x_j represents the plurality of code symbols, the index J is defined over the range $J \subseteq \{j : k - \underline{M} \le j \le k + \overline{M}\}$, M is the number of

code symbols in the plurality of code symbols, and N is the number of pilot symbols in the plurality of code symbols.

12. The apparatus of Claim 11, wherein evaluating the gain vector equation is performed iteratively with an initial condition $\hat{\theta}_0 = \mathbf{y} \equiv \frac{1}{N}\sum_{j' \in J'} y_{j'}$, and with an iteration formula:

$$\hat{\theta}_n = \frac{y + (1/N)(\sigma_p^2/\sigma_t^2)\left[\sum_{j \in J-\{k\}} g(x_j, \hat{\theta}_{n-1}) + d_{\pi(k)} x_k\right]}{1 + (M/N)(\sigma_p^2/\sigma_t^2)}$$

where $y_{j'}$ represents the plurality of pilot symbols and $J' \subseteq \{j' : k - \underline{N} \leq j' \leq k + \overline{N}\}$.

13. The apparatus of Claim 11, wherein using the gain vector to determine likelihood values of the designated code symbols comprises:

defining the likelihood values of the designated code symbol as a log likelihood ratio Λ_k in accordance with the following equation:

$$\Lambda_k = f_k(\hat{\theta}_-, -1) - f_k(\hat{\theta}_+, +1),$$

wherein

$$f_k(\vec{\theta}, d) \equiv \frac{1}{\sigma_t^2}\left\{\frac{(M/N)(\sigma_p^2/\sigma_t^2) + 1}{(2/N)(\sigma_p^2/\sigma_t^2)}\left\|\vec{\theta}\right\|^2 - \frac{N}{(\sigma_p^2/\sigma_t^2)}\mathrm{Re}\{\vec{\theta}^H y\} - d\,\mathrm{Re}\{\vec{\theta}^H x_k\} - \sum_{j \in J-\{k\}}\left|\mathrm{Re}\{\vec{\theta}^H x_j\}\right|\right\},$$

and σ_p^2/σ_t^2 is a pilot-to-traffic ratio.

14. The apparatus of Claim 1, wherein determining the gain vector relating the plurality of code symbols and the plurality of pilot symbols in accordance with channel characteristics comprises:

evaluating a gain vector equation defined by:

$$\hat{\theta} = \frac{y + (1/N)(\sigma_p^2/\sigma_t^2)\sum_{j \in J} g(x_j, \hat{\theta})}{1 + (M/N)(\sigma_p^2/\sigma_t^2)}$$

wherein σ_p^2/σ_t^2 is a pilot-to-traffic ratio, $g(\cdot,\cdot)$ is a predetermined function, x_j represents the plurality of code symbols, the index J is defined by the

relationship $J \subseteq \{j : k - \underline{M} \leq j \leq k + \overline{M}\}$, M is the number of code symbols in the plurality of code symbols, and N is the number of pilot symbols in the plurality of code symbols.

15. The apparatus of Claim 14, wherein evaluating the gain vector equation is performed iteratively with an initial condition $\hat{\theta}_0 =$ $\mathbf{y} \equiv \frac{1}{N} \sum_{j' \in J'} y_{j'}$, using an iteration formula:

$$\hat{\theta}_n = \frac{y + (1/N)(\sigma_p^2 / \sigma_t^2) \sum_{j \in J} g(x_j, \hat{\theta}_{n-1})}{1 + (M/N)(\sigma_p^2 / \sigma_t^2)}$$

where $y_{j'}$ represents the plurality of pilot symbols and $J' \subseteq \{j' : k - \underline{N} \leq j' \leq k + \overline{N}\}$.

16. The apparatus of Claim 14, wherein using the gain vector to determine likelihood values of the designated code symbols comprises:

defining the likelihood values of the designated code symbol as a log likelihood ratio Λ_k in accordance with the following equation:

$$\Lambda_k = \frac{2}{\sigma_t^2} \mathrm{Re}\{\hat{\theta}^H x_k\},$$

wherein the superscript H represents the Hermitian transpose of the gain vector.

17. An apparatus for determining a log likelihood ratio of a designated code symbol by using a plurality of code symbols and a plurality of pilot symbols transmitted over diversity channels, comprising:

a memory element; and

a processor configured to execute a set of instructions stored in the memory element, the set of instructions for:

receiving a frame of N' code symbols;

dividing the frame of code symbols into N'/K groups of code symbols, wherein the i^{th} group contains symbols with indices $iK + 1, \ldots, (i+1)K$;

setting a counter for i, ranging from 0 to $(i+1)K - 1N'/K$-1;

setting a plurality of indices as follows:

$J = \{iK+1-\underline{M}, \ldots, (i+1)K + \overline{M}\}$,

$J' = \{iK+1-\underline{N}, \ldots, (i+1)K + \overline{N}\}$,

$N = \underline{N} + \overline{N} + K$,

$M = \underline{M} + \overline{M} + K$;

setting an initial gain vector condition defining $\hat{\theta}_0 = \mathbf{y} \equiv \frac{1}{N}\sum_{j' \in J'} y_{j'}$;

iterating a gain vector equation for a predetermined number of iterations, the gain vector equation defined by:

$$\hat{\theta}_n = \frac{y + (1/N)(\sigma_p^2/\sigma_t^2)\sum_{j \in J} g(x_j, \hat{\theta}_{n-1})}{1 + (M/N)(\sigma_p^2/\sigma_t^2)},$$

wherein σ_p^2/σ_t^2 is a pilot-to-traffic ratio;

setting the last value of $\hat{\theta}_n$ as $\hat{\theta}$;

computing a value $\Lambda_k = \frac{2}{\sigma_t^2}\mathrm{Re}\{\hat{\theta}^H x_k\}$ for each $k = iK+1, \ldots, (i+1)K$; and

incrementing i and repeating the above steps so that a plurality of values $\{\Lambda_1, \ldots, \Lambda_{N'}\}$ is obtained.

18. A method for determining likelihood values of input data bits from a plurality of code symbols and a plurality of pilot symbols, comprising:

determining a gain vector relating the plurality of code symbols and the plurality of pilot symbols in accordance with channel characteristics; and

using the gain vector to determine likelihood values of a designated code symbol, wherein the input data bits are carried by the designated code symbol.

19. A method for determining a log likelihood ratio of a designated code symbol by using a plurality of code symbols and a plurality of pilot symbols transmitted over diversity channels, comprising:

receiving a frame of N' code symbols;

dividing the frame of code symbols into N'/K groups of code symbols, wherein the i^{th} group contains symbols with indices $iK+1, \ldots, (i+1)K$;

setting a counter for i, ranging from 0 to $(i+1)K - 1N'/K - 1$;

setting a plurality of indices as follows:

$$J = \{iK+1-\underline{M}, \ldots, (i+1)K+\overline{M}\},$$

$$J' = \{iK+1-\underline{N}, \ldots, (i+1)K+\overline{N}\},$$

$$N = \underline{N}+\overline{N}+K,$$

$$M = \underline{M}+\overline{M}+K;$$

setting an initial gain vector condition defining $\hat{\theta}_0 = \mathbf{y} \equiv \frac{1}{N}\sum_{j' \in J'} y_{j'}$;

iterating a gain vector equation for a predetermined number of iterations, the gain vector equation defined by:

$$\hat{\theta}_n = \frac{y + (1/N)(\sigma_p^2/\sigma_t^2)\sum_{j \in J} g(x_j, \hat{\theta}_{n-1})}{1+(M/N)(\sigma_p^2/\sigma_t^2)},$$

wherein σ_p^2/σ_t^2 is a pilot-to-traffic ratio;

setting the last value of $\hat{\theta}_n$ as $\hat{\theta}$;

computing a value $\Lambda_k = \frac{2}{\sigma_t^2}\mathrm{Re}\{\hat{\theta}^H x_k\}$ for each $k=iK+1,\ldots,(i+1)K$; and

incrementing i and repeating the above steps so that a plurality of values $\{\Lambda_1, \ldots, \Lambda_{N'}\}$ is obtained.

20. An apparatus for determining likelihood values of input data bits from a plurality of code symbols and a plurality of pilot symbols, comprising:

means for pre-processing the plurality of code symbols and the plurality of pilot symbols into a slowly time varying model;

means for determining a gain vector relating the plurality of code symbols and the plurality of pilot symbols to the slowly time varying model; and

means for using the gain vector to determine likelihood values of a designated code symbol, wherein the input data bits are carried by the designated code symbol.